ReCap and the Factory Design Utilities
A Great Combination

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Learning Objectives

- Discover techniques to clean up and orient a point cloud with Autodesk ReCap.

- Learn how to create a DWG™ overlay from a point cloud capture.

- Learn how to create your factory layout in context of a point cloud, and how to check for clashes with Autodesk Navisworks.

- Investigate the possibility of using a point cloud as a factory asset.

Description

Reality capture techniques are becoming commonplace in many aspects of design. The factory layout process is no different. From the clean-up and orientation of the point cloud to the possibility of using point clouds as factory assets, when it comes to utilizing point clouds with the Factory Design Utilities, there is a lot to consider. Join us in this class as we focus on the various techniques and workflows for capitalizing on point cloud captures in the factory layout process.

Your AU Experts

Rusty Belcher is a Manufacturing Application Expert working with IMAGINiT Technologies. Rusty provides implementation, training, and support services at every level for all Autodesk Manufacturing products. His specialty involves the integration of 3D design practices into manufacturing production environments. As an instructor and mentor, IMAGINiT regularly receives outstanding reviews of his impact to their organization.

Rusty started his career as a structural steel fitter at Newport News Shipbuilding. He is a graduate of the Newport News Shipbuilding Apprentice School and worked in the shipyard's Mold Loft engineering division.

Over the past several years Rusty has worked directly with Autodesk to develop and author the current Factory Design Suite training courseware, has also developed, and recorded many of the tips and tutorial videos available on the Factory Design Suite YouTube Channel.

Reality Capture and Layout Design

It is amazing how fast the Reality Capture techniques have changed how design workflows are accomplished in modern CAD applications. In early CAD designs, everything was created using conventional 2D practices. Design workflows changed to include the advances of 3D solid modeling. Now our workflows are evolving again to include laser scan point clouds and various forms of reality capture.

Reality Capture techniques are now commonplace in many aspects of layout design. If you are utilizing the Factory Design Utilities to arrange equipment in an existing facility (Brownfield), a laser scan of the new facility is almost expected. Of course, you can manage the project with a 2D AutoCAD floorplan, but nothing provides as accurate a representation of an existing space as a laser scan point cloud.

Autodesk ReCap and Factory Design Utilities – File Formats

When it comes to utilizing Point Clouds in the Factory Design workflow there is one general rule you must follow. Point Clouds used in Autodesk Inventor must be attached via Autodesk Recap. Autodesk Inventor only recognizes the point cloud formats generated by Autodesk Recap. You can only insert a RCP (ReCap Project file) or an RCS (ReCap Scan). It is important to note, that the Navisworks application does recognize point cloud formats from various laser scanners, but the layout techniques used in the Inventor application utilize ReCap scans exclusively.

Laser Scan Formats and Applications in the Product Design Collection		
Autodesk AutoCAD	**Autodesk Inventor**	**Autodesk Navisworks**
Autodesk ReCap (*.rcp, *.rcs)	Autodesk ReCap (*.rcp, *.rcs)	Autodesk ReCap (*.rcp, *.rcs)
		ASCII Laser (*.asc, *.txt)
		Faro (*.fls, *.fws, *.iQscan, *.iQmod, *.iQwsp)
		Leica (*.pts, *.pts)
		Riegl (*.3dd)

Cleaning Up Your Point Cloud

Autodesk ReCap serves several critical purposes in the general workflow for utilizing point clouds in the Inventor environment. Its primary purpose is to translate the point cloud so it can be imported into the application. Its secondary purpose is equally important. Autodesk ReCap allows users to clean the point cloud and isolate the points that are necessary to the overall design. It is important to remember, that a large number of points will slow down the performance of the Inventor application. So any points that can be removed from the imported Scan will increase the performance of the Inventor application.

Traditional Points Removed from Facility Scans
Laser Scans are traditionally used to represent the facility housing the layout being developed. Because the Factory Design Utilities provide a general floor and 3D assets, these existing elements of the Point Cloud are removed before importing the scan into Inventor.
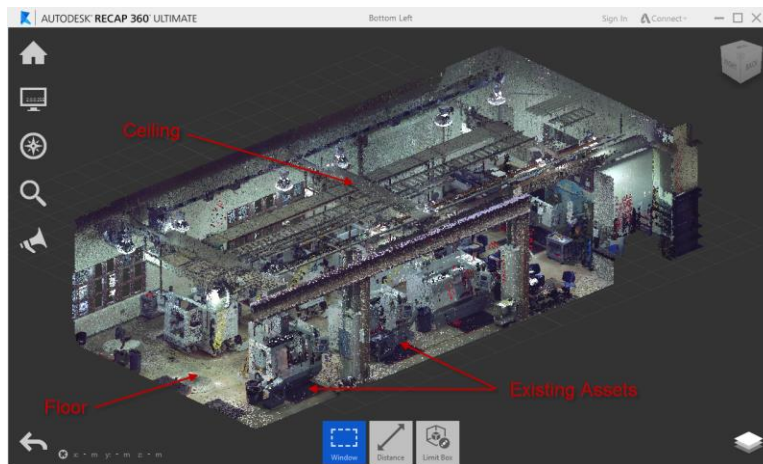

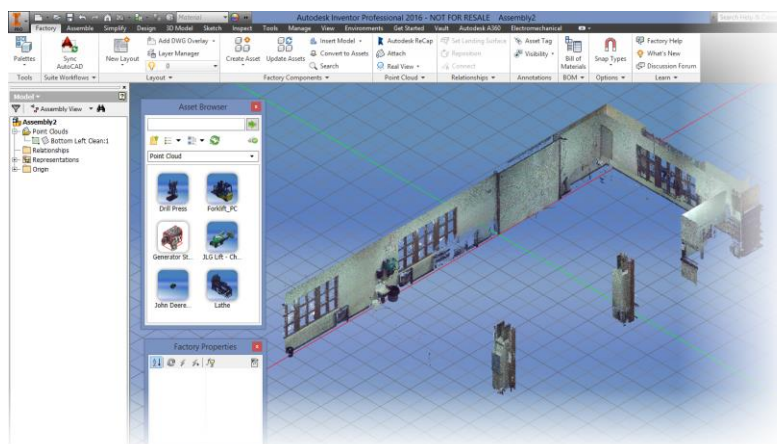FIGURE 1: ELEMENTS TRADITIONALLY REMOVED FROM FACILITY SCAN IN RECAP
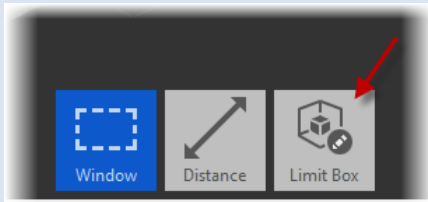

FIGURE 2: FACILITY POINT CLOUD IN INVENTOR

Commands for Point Removal or Isolation

ReCap has several point selection and isolation tools that can be used to remove or hide points in a point cloud. The commands utilized in this example are listed below.
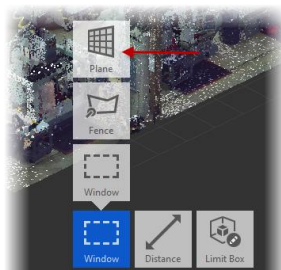
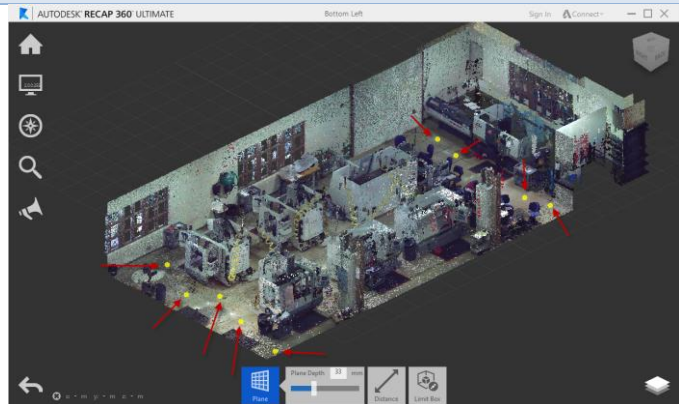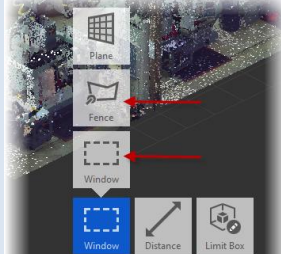| Commands for Point Removal or Isolation	
Limit Box Allows you to hide points by adjusting a bounding box. **Note**: Hidden points can be re-displayed by adjusting or resetting the Limit Box.	
Plane Select Specify points to define a plane. Use the Delete Key to erase the selected points.	
Fence / Window Select Draw a Fence or Window around Points to select. Use the Delete Key to erase the selected points.	
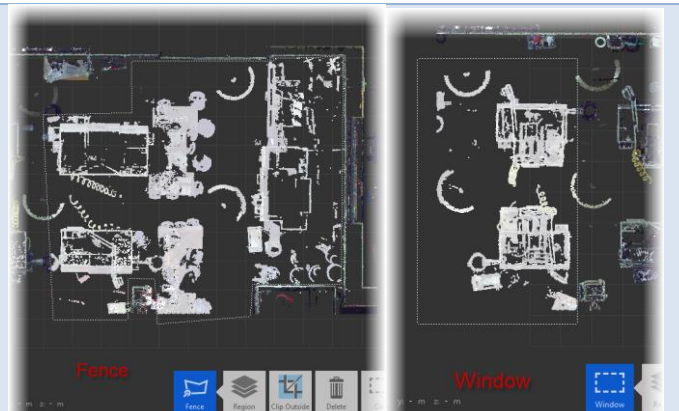
Perspective Toggle

Toggles between the Perspective and Orthographic view. Orthographic view allows for easier point selection.
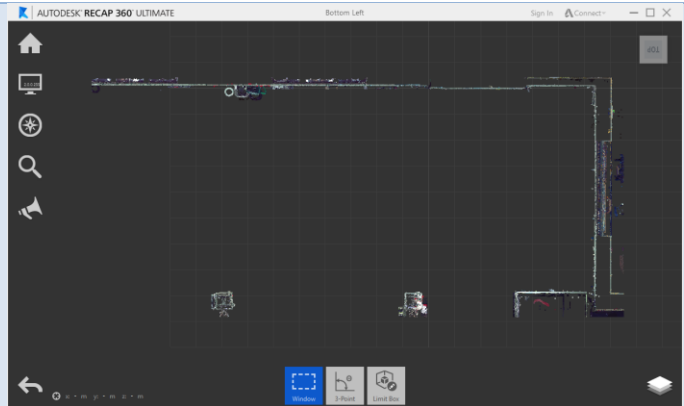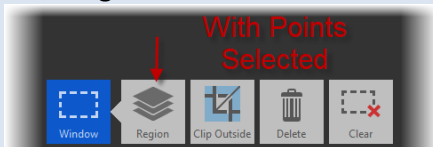

Update Origin

Allows users to establish the coordinate system based on features displayed in the cloud. This coordinate system is honored when the cloud is inserted into a CAD application.
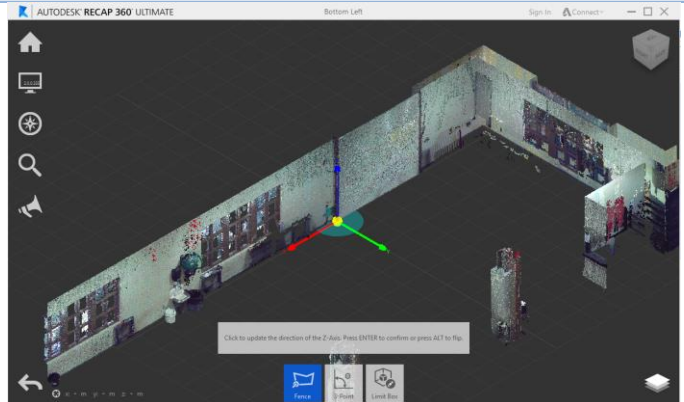
Scan Region

With Points Selected, the Scan Region option becomes available. Use Regions to segregate different areas of the cloud. Regions provide locking and visibility for the selected points. Note: Regions are only transferred to a CAD application via the RCP file extension.
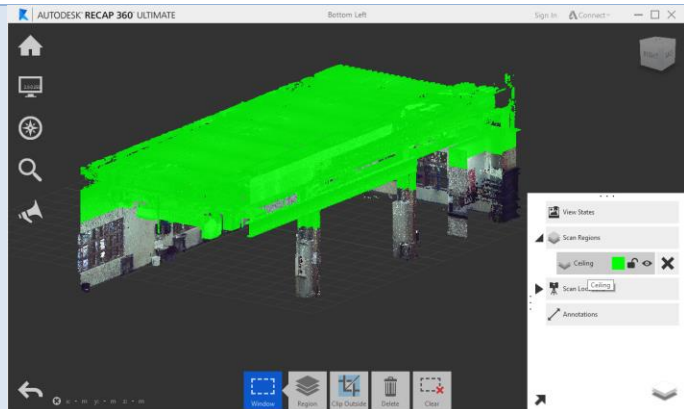
Creating Drawings from Point Clouds using Autodesk Applications

Working with a point cloud in the Inventor environment is nice, but the point cloud has limitations when it comes to actually referencing it in the layout design. In most cases a 2D drawing of the point cloud is required for a Factory Layout. When faced with this need, users have traditionally resorted to manually tracing the cloud in AutoCAD. There are some tools available that make extracting section lines from the cloud easier but there is no single method for automatically recognizing the walls and equipment in the point cloud. The Product Design Collection offers many tools to aid in this process.

| Point Cloud to Drawing Conversion Techniques	
Manual Trace of Scan in AutoCAD	A simple manual trace of the point cloud using classic AutoCAD drawing tools.
Manual Trace of Scan in Inventor	The point cloud is added to an Inventor part file and a simple trace is created on a sketch plane.
Raster Design Trace / Conversion of Scan Image	An orthographic image is generated from the scan and inserted into AutoCAD. The picture is then converted to vector data using the Raster Design tools.
Automatic Generation of Scan Section Lines in AutoCAD	The PCEXTRACTSECTION command is used to automatically generate lines from a point cloud section.
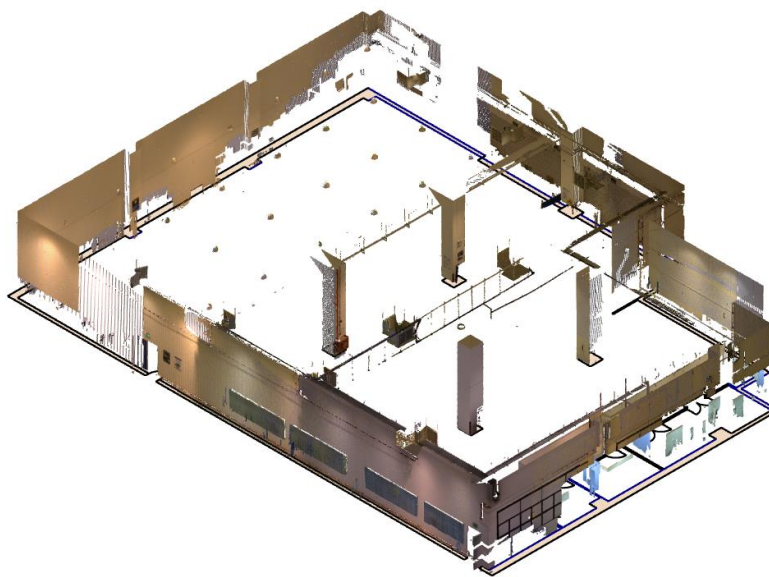
FIGURE 3: SKETCH LINES ARE OFTEN ADDED TO SUPPORT POINT CLOUD SCANS

Tracing a Point Cloud

By far, the most common method of generating a 2D vector drawing from a point cloud involves simply tracing the points in the cloud. Tracing the point cloud is usually the simplest solution to this requirement. This can be accomplished with a variety of applications available in the Product Design Collection.
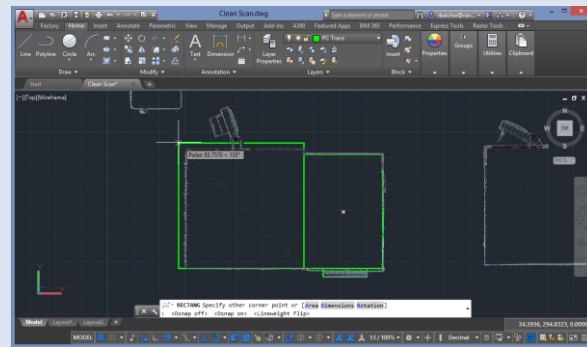
Point Cloud Tracing Techniques – AutoCAD / Inventor

Tracing in AutoCAD

AutoCAD provides a perfect environment to produce point cloud tracings.

Tips

- Attach the Point Cloud to its default / proper position and orientation.
- Ensure Orthographic Mode is active.
- Use a small point size for clarity.
- Use the Polyline command to ensure a planer result.

Tracing in Inventor

Point Clouds are also easily traced in Autodesk Inventor.

Tips

- Create a part file (.ipt) to hold the cloud and the trace sketch.
- Attach the Point Cloud to its default / proper position and orientation.
- Create your sketch on one of the default work planes if possible. (Usually the XY plane)
- Use Color to format the lines as needed.
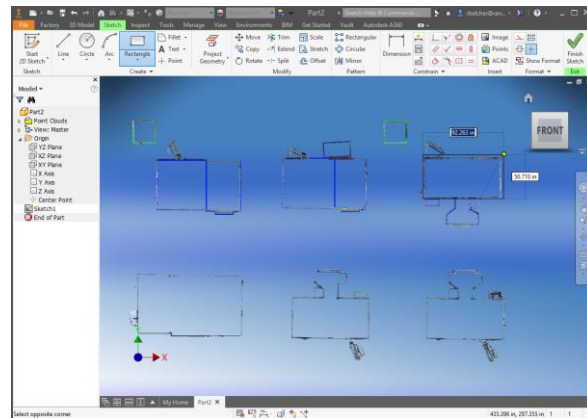
Tracing Point Clouds with Raster Design

There are occasions where the actual cloud is too large to attach to our CAD file. This can make generating the tracing directly from the cloud difficult or impractical. These situations are the perfect opportunity to utilize the Raster Design tools now included in our AutoCAD applications. We simply generate an image or screenshot of the cloud and insert the raster file into our AutoCAD application. We then utilize the Raster Design Tools to convert the image of the points to lines or polylines.
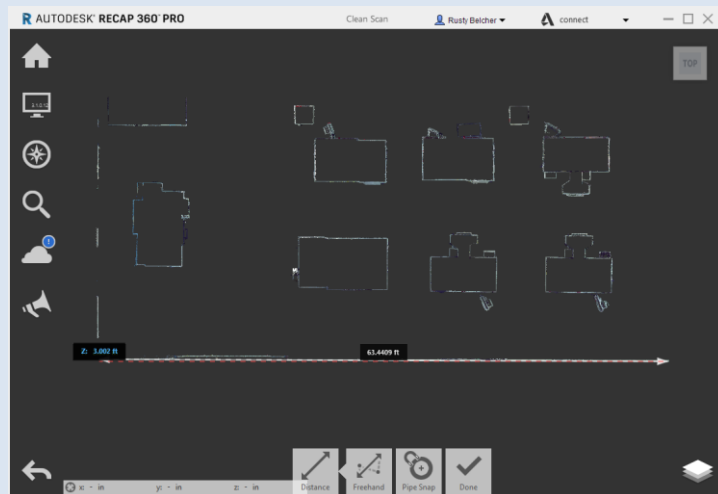
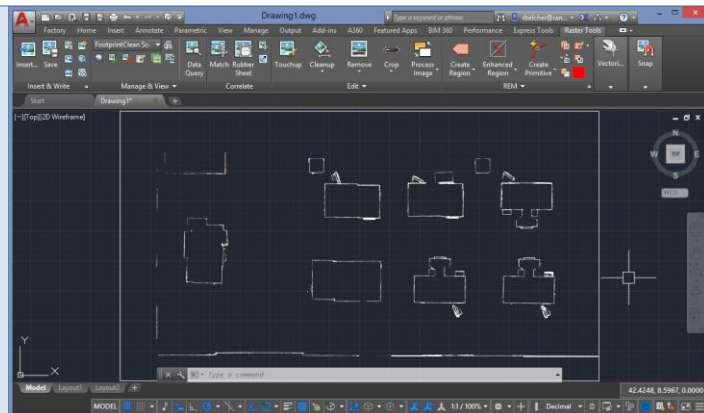| Tracing Point Clouds with Raster Design	
Clean up and orient the scan with ReCap Use Autodesk ReCap to clean and orient the scan displaying only the points necessary to the desired footprint. You will also need an accurate measurement of a prominent edge or feature. Tips • Remove or Hide any unnecessary points. • Position the cloud establishing the proper X, Y, and Z orientation. • Setup a Top / Orthographic View. • Set the appropriate units and record an accurate measurement of a prominent edge or feature.	
Generate a Screenshot or Image ReCap 360 Pro 2016 now has the ability to generate images directly from the cloud. If you are using the basic version of ReCap you can simply generate a screenshot and save it to the desired image type. The image shown here was generated from ReCap 360 Pro.	
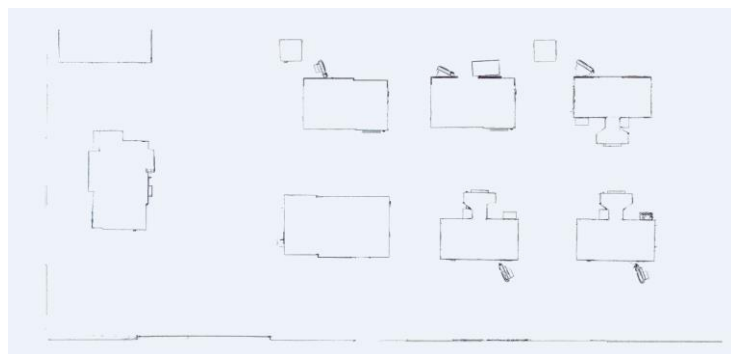
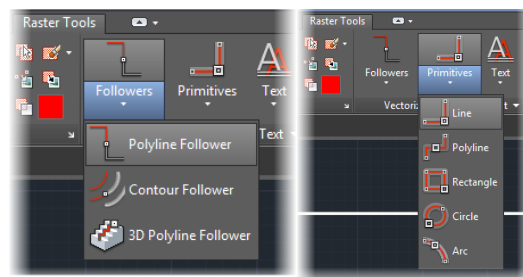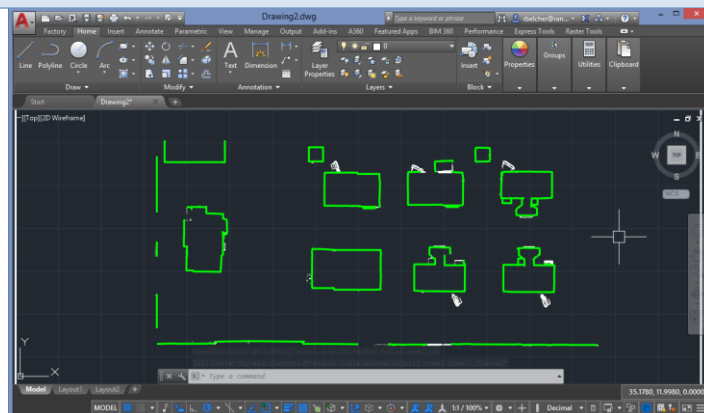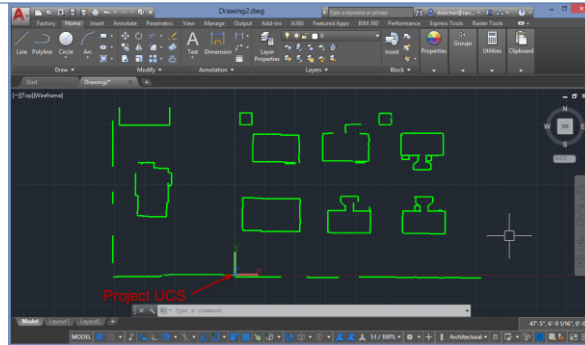|	
Use Raster Design to Insert the Image into an AutoCAD File Tips • Convert the Image to Bitonal.	
Use the Raster Design Tools to Trace / Convert to Vector Lines Tools • Polyline Follower • Primitive Line • Primitive Polyline • Primitive Rectangle	
Scale the Image and Vector Data to Full Scale Use the measurement taken from the scan in ReCap to adjust the footprint to full scale.	
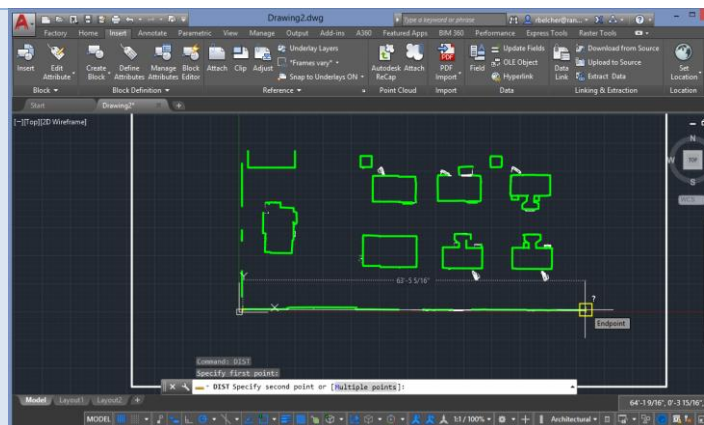
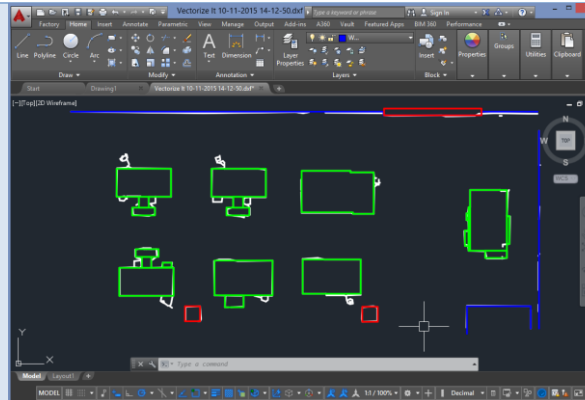|	
Move the Footprint to the Correct Position Tip Make sure to use a consistent origin point for all factory layout files.	
Including Precise Geometry Add conventional geometry to the converted lines to accurately display the footprint of the facility and machines.	
Factory Design Utilities / DWG Overlay The finished drawing is then used as the DWG Overlay with the Factory Design Utilities (Inventor).	
Placing Factory Assets in Context The 3D assets can now be placed on the footprint. The original point cloud can also be added to the layout.	
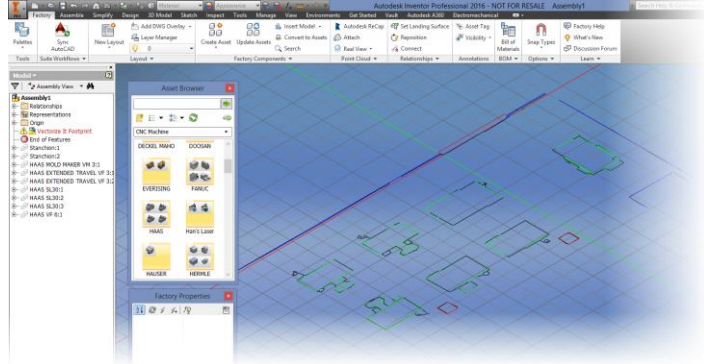
Automatic Section Line Extraction

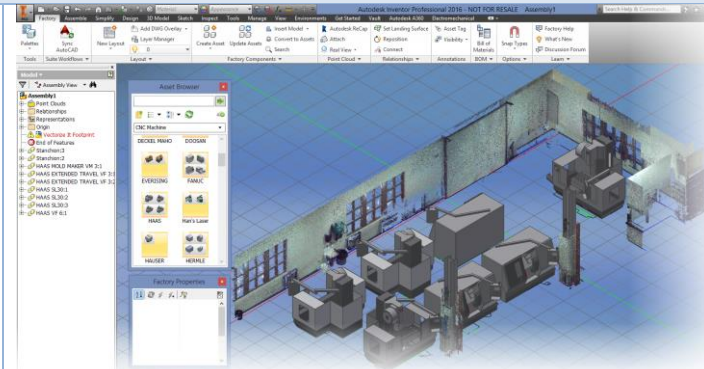There are other means to extract section lines from a point cloud. The newer versions of AutoCAD allow users to section a point cloud and generate section lines using the PCEXTRACTSECTION (Point Cloud Extract Section) command. This command works fairly well but it relies on a programmed analysis of points in space and how those points line up. Some manual clean-up will be required.
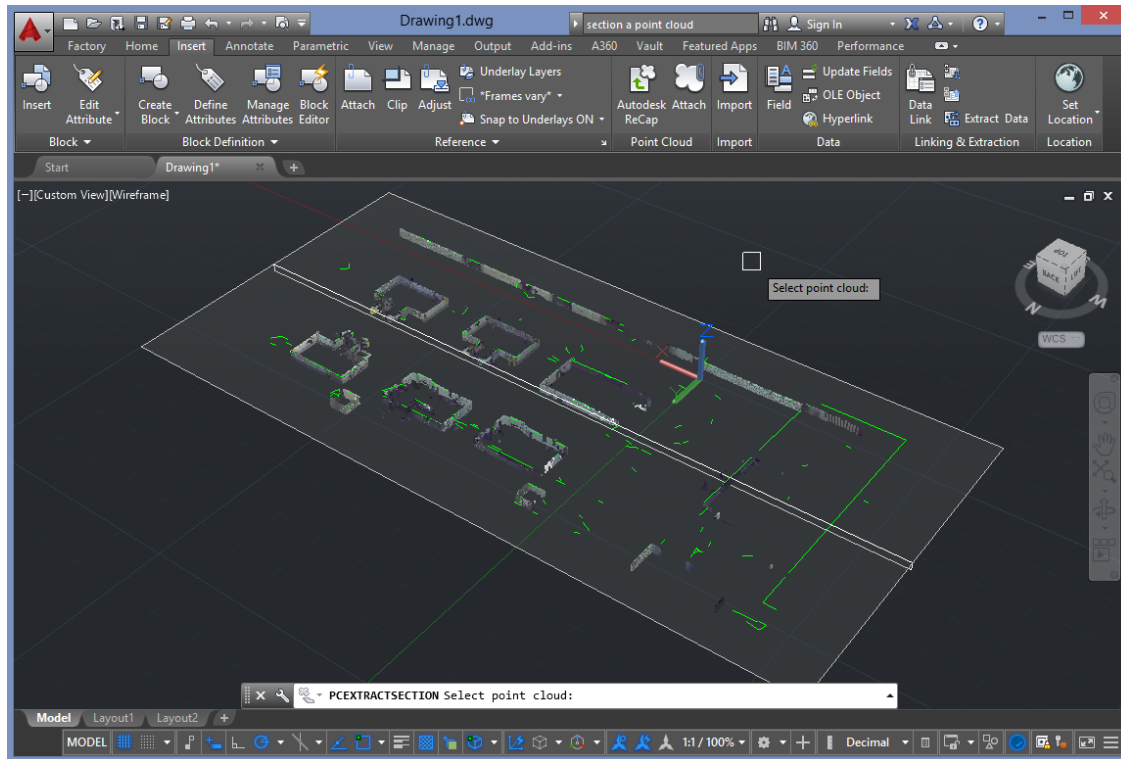

FIGURE 4: AN ALTERNATIVE METHOD TO EXTRACTING SECTIONS FROM POINT CLOUDS

Vectorize It – Discontinued

In 2014, Autodesk introduced a tool called Autodesk Vectorize It. This iPad app allowed users to automatically trace raster images and generate vector drawings in .dxf format. This application combined with an orthographic screenshot of the ReCap point cloud provides the means to convert a section of point cloud data into a 2D vector drawing. This drawing can then serve as the footprint used in FDS as the DWG overlay. The technology preview was discontinued and is no longer available, but would fit perfectly into this workflow.

Accuracy

Whichever method you utilize to extract section lines from a point cloud, please remember the accuracy of your final drawing will not be exact. If you utilize the Vectorize It approach, the process of scaling your drawing based on the ReCap dimension does require some human analysis and interaction. The human aspect of this process will diminish the overall accuracy of the final drawing. But, when it comes to facility layout, location tolerances can be relatively large and this process should work just fine.

Creating a Factory Layout in Context of a Point Cloud

The Factory Design workflow utilizes Point Cloud scans to represent the facility and the environment that houses the layout design. Working with a reality capture of the actual facility offers several advantages depending on which application you are working in.

Inventor
The 3D layout environment of the Factory Design Utilities is centered in the Inventor application. Including a point cloud in the factory layout allows us to place 3D factory assets in context of the actual walls, windows and ceiling included in the scan. Having the full facility present and represented during the layout design process reveals many additional issues that are not as easy to see using a traditional 2D DWG Overlay.
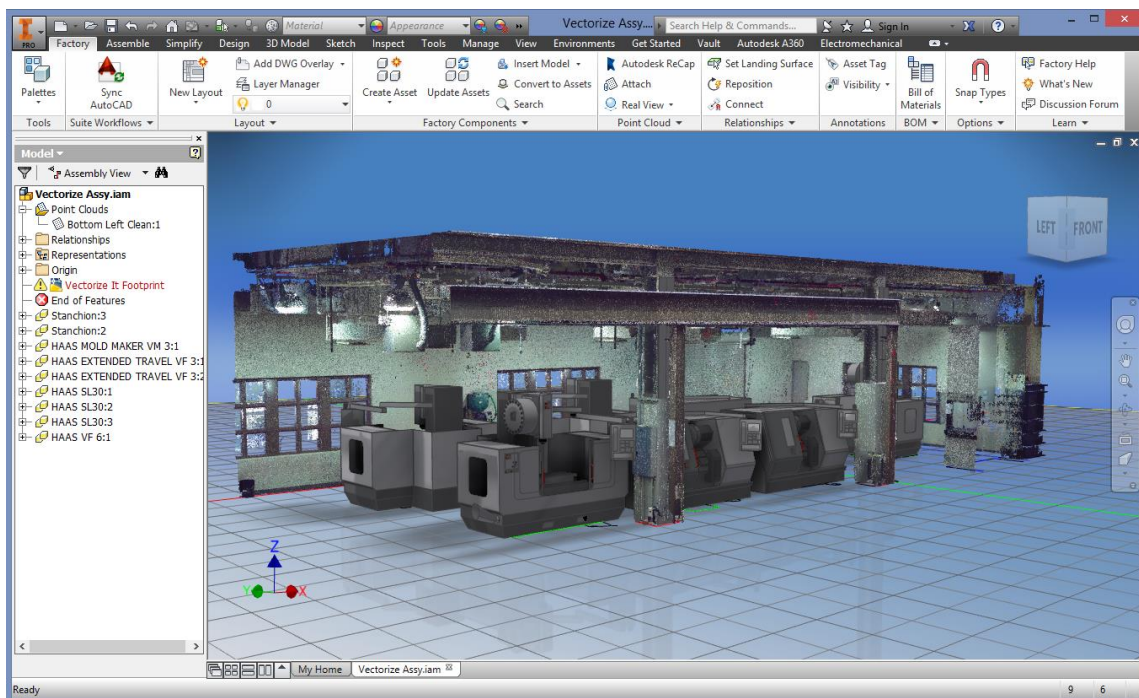

FIGURE 5: ASSETS PLACED IN CONTEXT OF A POINT CLOUD - INVENTOR

Navisworks

Clash Detection and Interference Analysis is a major issue for every layout design. It is extremely important to determine how your layout design will integrate into an existing space or facility. Point Clouds have traditionally been excluded from interference analysis because they are made up of simple points with no solid geometry. The Navisworks application provides a robust Clash Detection analysis for all 3D objects including solid geometry, mesh geometry or point clouds. The Clash Detective tool (part of Navisworks Manage) provides the workflow to perform a clearance analysis between your digital 3D asset models and the laser scan point cloud.
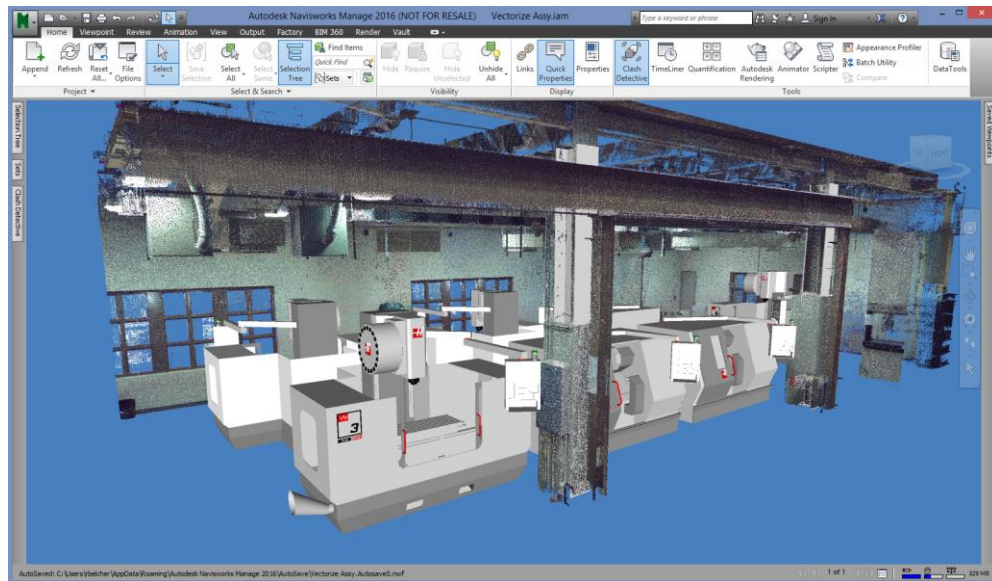

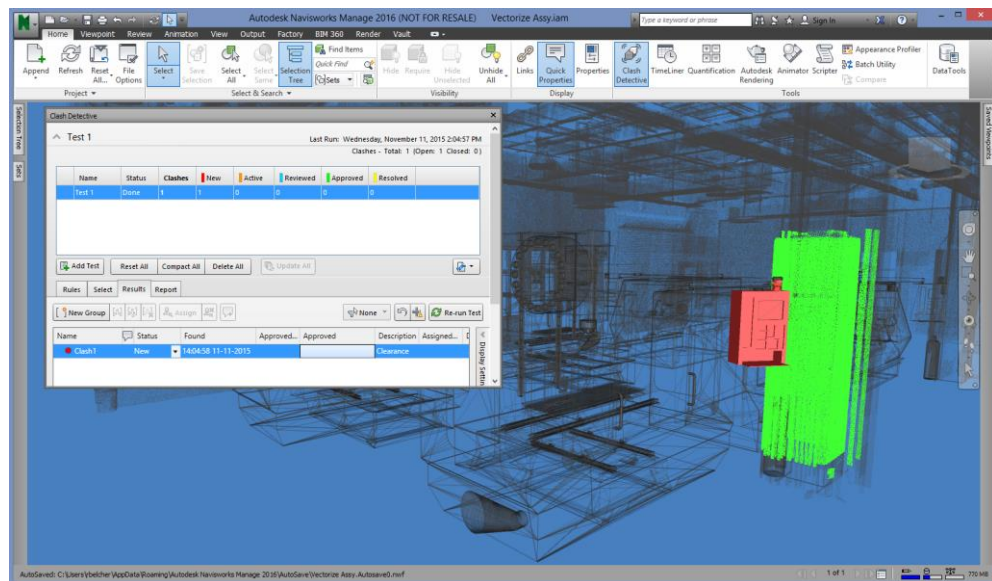FIGURE 6: ASSETS PLACED IN CONTEXT OF A POINT CLOUD - NAVISWORKS

FIGURE 7: CLASH DETECTED BETWEEN SOLID DATA AND POINT CLOUD SCAN - NAVISWORKS
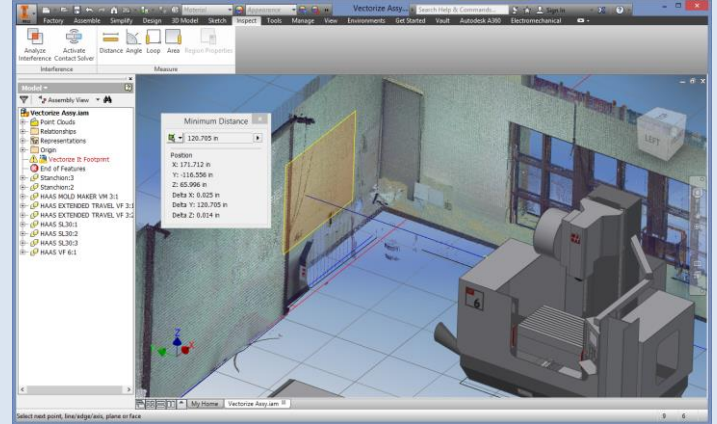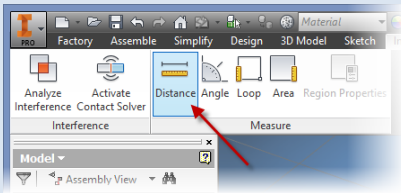
Additional Tools Available for Point Cloud Analysis

The following list outlines several additional tools available for Point Cloud analysis in the Autodesk Product Design Collection.

Point Cloud Analysis Tools in PDC	
Inventor - Measuring a Distance to a Point Cloud Plane A group of planer points can be selected as a plane via the Measure Distance Command in Inventor. 	
Inventor - Cloud Point Places a work point on any single cloud point. The work point can be used to generate additional work features, or as a selectable location for asset insertions or descriptors. 	
Inventor - Cloud Plane Places a work plane on a group of planer points. 	
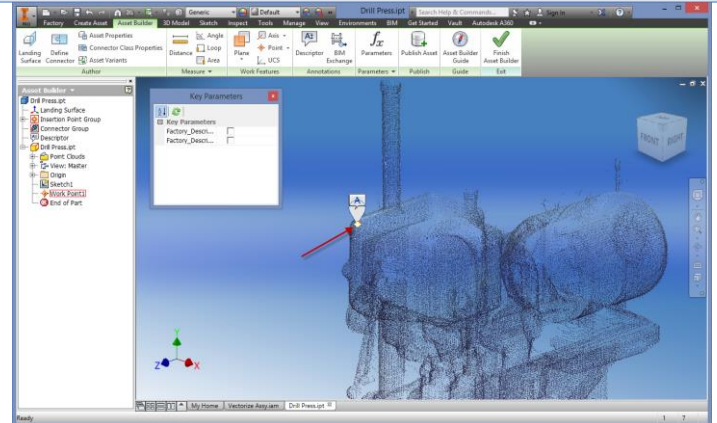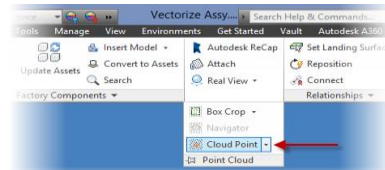
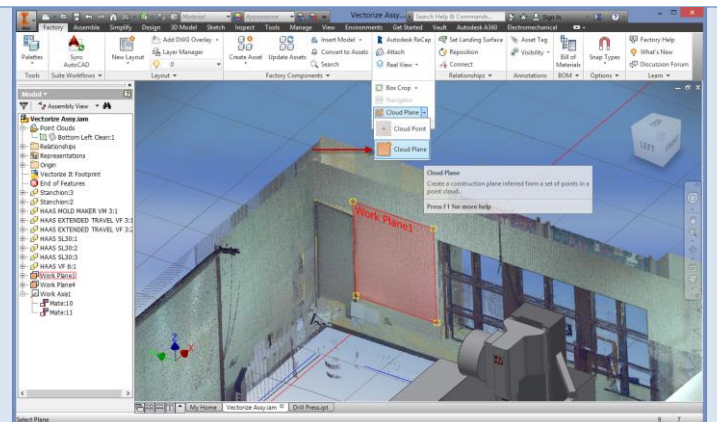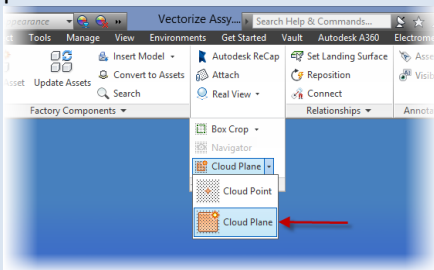|	
Inventor - Box Crop Allows users to hide a portion of the point cloud. **Note**: You can hide the points inside or outside the box.	
Navisworks – Point Display Toggles the visibility of points in the scene.	
Navisworks – Clash Detective – Clearance for Points Performs a clearance analysis between solids and points.	
AutoCAD – Point Cloud Tools AutoCAD offers several point cloud analysis tools that allow users to extract geometric information from a scan. - Extract Section Lines - Extract Edge - Extract Corner - Extract Centerline of Cylinder	
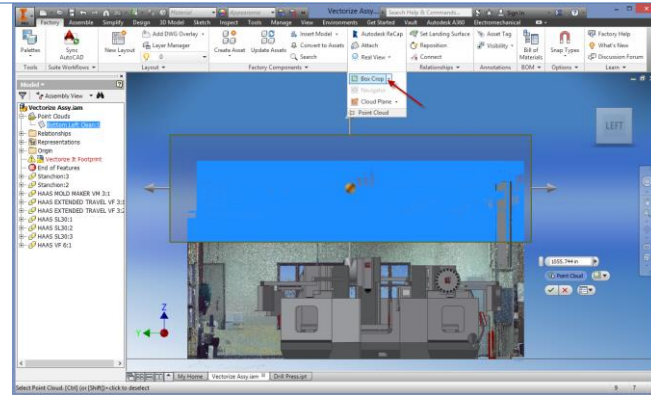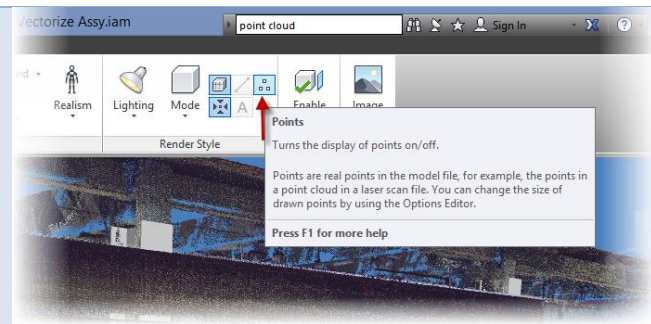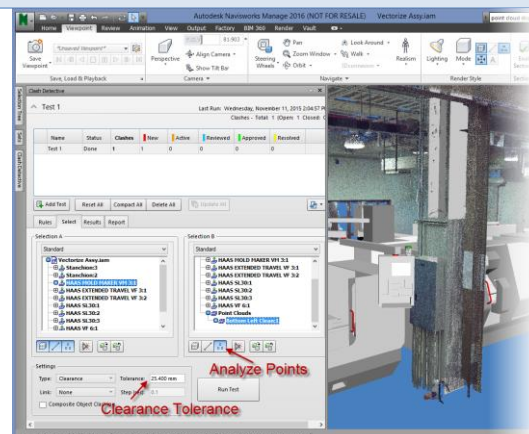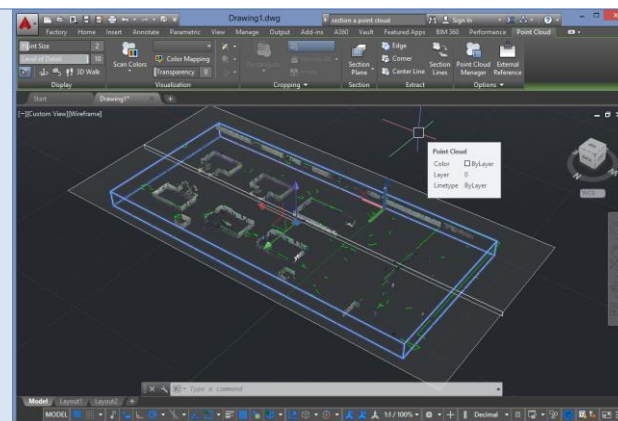
Using a Point Cloud as a Factory Asset

The Factory Design workflow traditionally utilizes Point Clouds to represent the outside defining limits of the layout space. Scans are typically used to represent the walls, floor, and ceiling of the area under development. However, it is also possible to turn the scanner inward creating a point cloud containing the size and shape of piece of equipment. This leads to the possibility of using a point cloud scan as a factory asset instead of a solid model.

The prevalence of reality capture and point cloud technology is much more common in today's manufacturing environment. Point clouds and scanned meshes are becoming a regularly used design tool for modeling applications and 3D printers. In many cases, you can produce a fairly good quality point cloud with pictures from your camera phone. In this section we will outline the process of generating a point cloud from photos using the new ReCap Photo service. The point cloud we generate will be used as an asset for the Autodesk Factory Design Utilities.
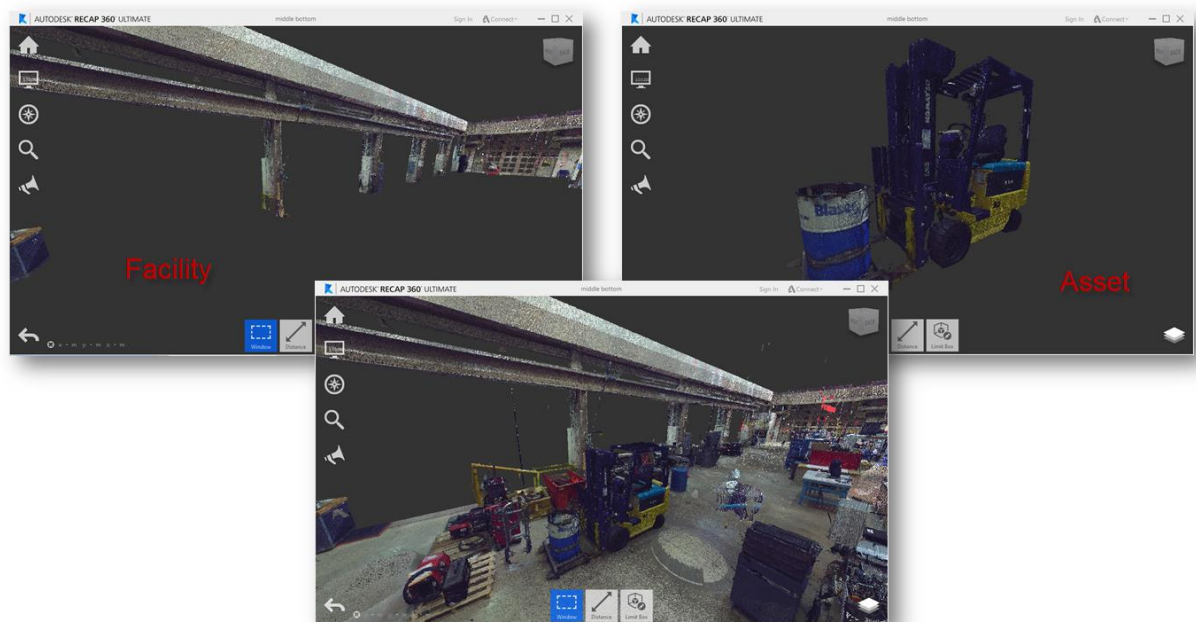
FIGURE 8: A POINT SCAN CLEANED TO IN WAY OF THE FACILITY AND AN ASSET.

Why would I want to use a Point Cloud instead of a Solid Model?

There are several reasons to utilize a point cloud in place of a solid model. In many cases, point clouds can be generated from scanners or cameras in much less time than that required to produce a standard solid model using conventional 3D practices. In many design workflows, the final form of the machine is not known so solid models must be created as digital prototypes or digital representations. But in many cases, the machine is already built and sitting on the factory floor. In this case, it is much easier and efficient to utilize reality capture tools to generate a point cloud of the actual machine, instead of developing a 3D solid model from hundreds of time consuming, manual measurements

Generating a Point Cloud with ReCap Photo

The prevalence of reality capture and point cloud technology is much more common in today's manufacturing environment. Point clouds and scanned meshes are becoming a regularly used design tool for modeling applications and 3D printers. It is important to remember, you don't need an expensive laser scanner to generate a reliable point cloud. In many cases, you can produce a fairly good quality point cloud with pictures from your camera phone. In this section we will outline the process of generating a point cloud from photos using the new ReCap Photo service.

The Pictures

The process starts off by taking many pictures of the machine from all directions and angles. It is important to include the entire machine in every picture and to take pictures from high and low angles. Every machine will be different, but in general it will require about 60 pictures to produce a decent point cloud. Some machines will require more, some less. There are several other criteria to keep in mind when photographing the machine:

- **Pictures from all Angles** – Take pictures every 5 to 10 degrees as you circle the machine. Use a ladder to obtain images from higher positions as you circle the machine again.
- **Avoid Reflections or Glare** – Reflective Surfaces are very difficult to stitch in the final scan.
- **Color Contrast** – The machine should contrast with the surrounding background.
- **Consistent Light Source** – The light source should remain constant in a single position (No Flash).
- **Textured Surfaces are Preferred** – Textured Surfaces are much easier to stitch in the final scan.

ReCap Photo – ReCap360.autodesk.com

Taking the pictures is the hard part. Once you have the pictures, generating the point cloud is very easy. Simply login to ReCap360.autodesk.com, then proceed to start a new project and upload the pictures. You will be notified via e-mail when the scan is complete. When your scan is finished you can download it in various mesh and point cloud formats. For this example we will download the .rcs (ReCap Scan) and open it with Autodesk ReCap.
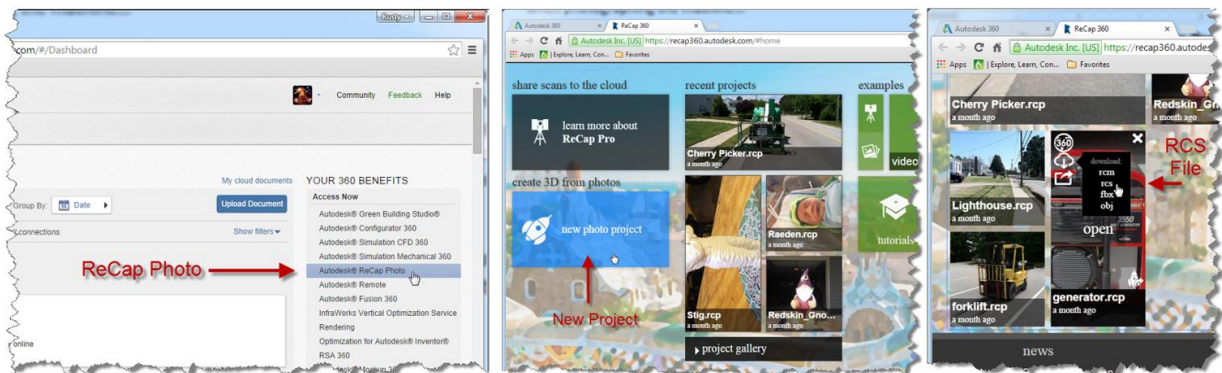

FIGURE 9: ACCESS RECAP PHOTO FROM YOUR AUTODESK 360 ACCOUNT

Autodesk ReCap

Autodesk ReCap is the tool we use to interact with the point cloud scan. ReCap allows us to clean up the scan, easily removing any unnecessary points from the point cloud. In this example the points that represent the floor were removed from the cloud. Autodesk ReCap also allows you to adjust the orientation of the cloud so the X, Y, and Z axis of the cloud are aligned to the machine and not arbitrarily set by the scan file.
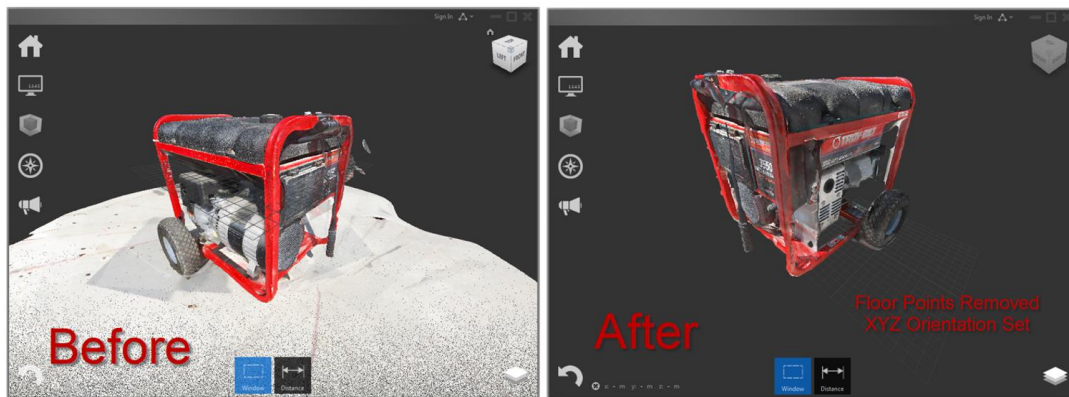

FIGURE 10: AUTODESK RECAP IS USED TO CLEAN UP THE SCAN AND RE-ORIENT THE CLOUD FOR FUTURE USE

Autodesk Inventor and the Factory Design Utilities

There are many methods of utilizing the point cloud in your design software. In this scenario we will be using the point cloud to represent a factory asset. As we stated before, generating a 3D solid model of the machine will require many manual measurements and several hours of modeling time. Using the point cloud as the asset will save us quite a bit of time and will function just as well as the 3D model representing the machine and the space required for the asset.

The asset creation process starts by inserting the point cloud into an Inventor part file. The orientation of the cloud, set in Autodesk ReCap, will be utilized when the cloud is inserted into Inventor. The original point cloud was generated in Meters and needs to be scaled to the proper size. Inventor allows you to re-orient the point cloud and apply the proper scale factor to the points. A single measurement of the actual machine is needed to determine the proper scale factor.
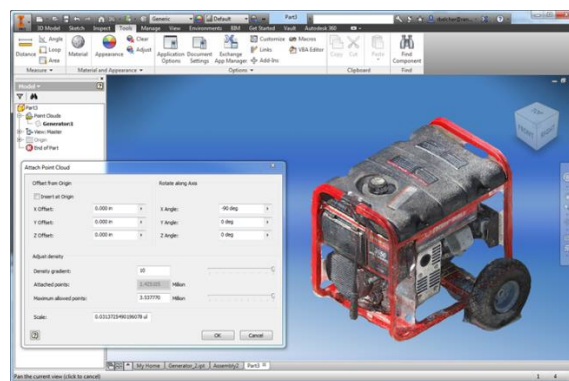

FIGURE 11: POINT CLOUDS CAN BE ORIENTED AND SCALED TO SUIT THE INVENTOR ENVIRONMENT

Publish the Asset with a 2D Representation

To fully utilize the cloud as a factory asset, you need to add a 2D sketch showing the top view of the machine. This sketch is placed at the bottom of the cloud where the machine would sit on the floor. The 2D sketch contains a simple trace of the major design features of the machine's top view. From this point on, we will use the standard asset publishing process with a few exceptions. The work plane containing the sketch will act as the landing surface and points on the sketch will be utilized as insertion points. When we publish the asset, we will make sure to select Publish Sketch as the 2D representation in the Asset Publish dialog.

Publishing the sketch is important for a couple of reasons. The sketch is utilized to represent the point cloud asset in 2D environments like AutoCAD or Inventor drawing views. The sketch also provides a selection and gripping point allowing you to easily move and manipulate the cloud asset in the factory layout assembly.
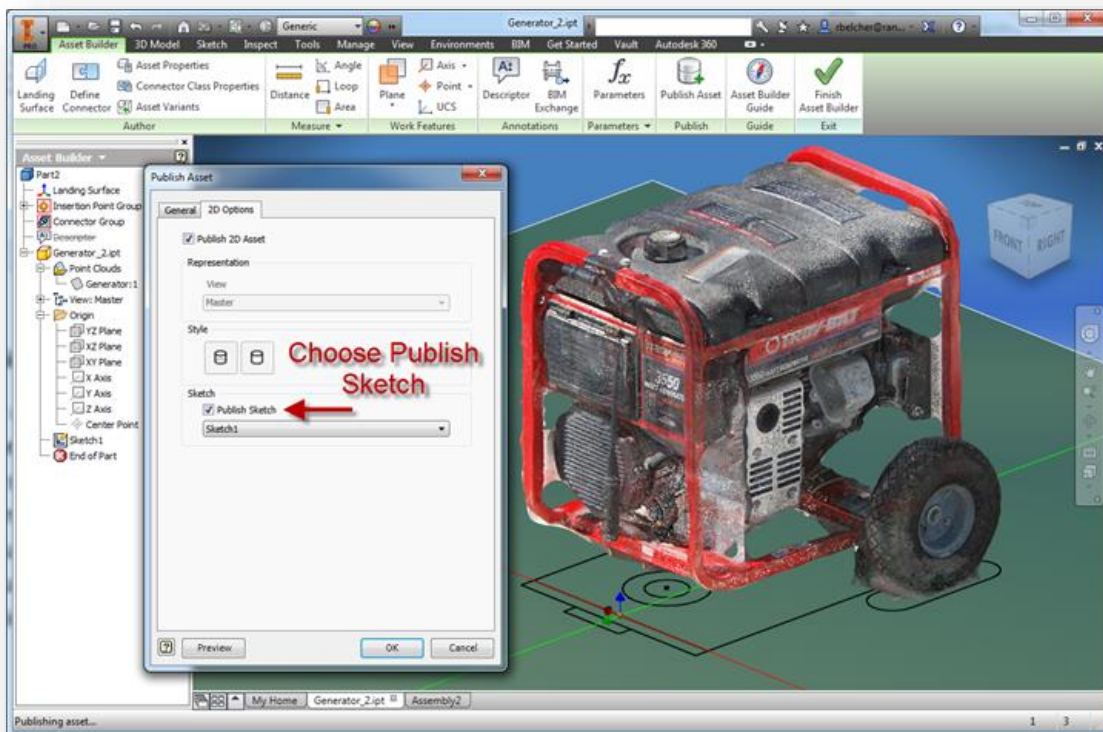

FIGURE 12: A 2D SKETCH DEPICTING THE TOP VIEW OF THE MACHINE IS ADDED TO THE CLOUD PRIOR TO PUBLISHING

The Pros and Cons of using a Point Cloud as a Factory Asset

There is no doubt that 3D modeling is the overwhelming choice for the creation of 3D factory assets. However, utilizing a point cloud as a factory asset offers several advantages. Factory Design Utility users should balance the pros and cons of the Point Cloud workflow before using a scan as a factory asset. The Pros and Cons of the Point Cloud Asset workflow are listed below.

| Pros and Cons of the Point Cloud Asset Workflow	
Pros	**Cons**
Why create a 3D solid model of a piece of equipment that actually exists on your shop floor?	3D modeling is the traditional method.
The creation of a point cloud can be faster than the 3D modeling process.	Point Clouds are not as accurate as Solid Models.
The creation of a point cloud can be easier than the 3Dmodeling process.	Point Clouds don't have mass, volume, or traditional surfaces usually required for downstream use.
Solid Models require many manual measurements.	Solid Models have a smaller digital footprint and do not require an external reference.
Designers must be experienced to create 3D models.	Scanning Technology must be acquired in order to generate Point Cloud scans.
Point Clouds automatically transfer from Inventor to Navisworks. (2016 Release)	
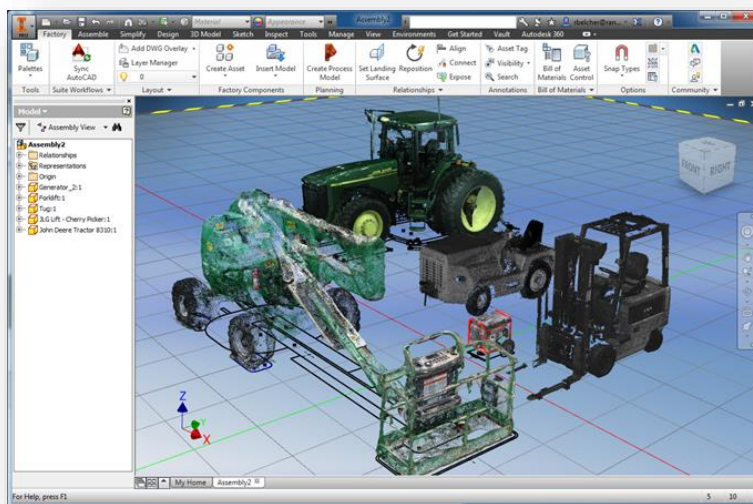
FIGURE 13: VARIOUS POINT CLOUD ASSETS

ReCap and the Factory Design Utilities – A Great Combination - Conclusion
Many manufacturers have recently adopted some level of reality capture workflows. Reality Capture applications like 123D Catch and ReCap Photo allow any designer to take advantage of these workflows without incurring the significant cost of a high end laser scanner. Regardless of your current reality capture capabilities, I hope this presentation has opened your eyes to the level of Point Cloud integration and support available in Autodesk Factory Design workflow. When it comes to designing a layout space in context of reality, Autodesk ReCap and the Autodesk Factory Design Utilities make a Great Combination.

Note: The assets highlighted in this demonstration are available in the Factory Design Utilities Asset Warehouse. If you would like to download the assets and review their functionality, simply search the FDS Asset Library with the Key Words "Point Cloud".